

**OPERATION, MAINTENANCE, MONITORING
AND OPTIMIZATION REPORTING OF
SOIL AND GROUNDWATER REMEDIATION SYSTEMS**

PURPOSE AND APPLICABILITY OF THIS FORM: Completion of this form is required under s. NR 724.13(e), Wis. Adm. Code. Use of this form is mandatory. Failure to submit this form as required is a violation of s. NR 724.13, Wis. Adm. Code, and is subject to the penalties in s. 144.99, Wis. Stats. This form must be submitted every six months for active soil and groundwater remediation projects and every twelve months for passive (natural attenuation) remediation projects that are regulated under the NR 700 series of Wis. Adm. Code. Specifically, for sites meeting any of the following criteria:

- Soil or groundwater remediation projects that report progress in accordance with s. NR 700.11(1), Wis. Adm. Code.
- Soil or groundwater remediation projects that report progress in accordance with s. NR 724.13(3), Wis. Adm. Code. (Note: s. NR 724.13(3) requires progress reports for operation and maintenance of active systems to be submitted every three months however the Department considers submittal of this form every six months to satisfy the requirements of the rules, unless otherwise directed by the Department on a site specific basis.)
- Soil or groundwater remediation projects that report progress in accordance with s. NR 724.17(3), Wis. Adm. Code. (Note: s. NR 724.17(3) requires progress reports every time that samples are collected however the Department considers submittal of this form every twelve months to satisfy the requirements of the rules for monitoring natural attenuation, unless otherwise directed by the Department on a site specific basis.)

Submittal of this form is not a substitute for reporting required by Department programs such as Wastewater or Air Management. Personally identifiable information on this form is not intended to be used for any other purpose than tracking progress of the remediation by the Bureau for Remediation and Redevelopment.

Please refer to the instructions that are attached to the back of these forms starting on page INS-1. In all cases, when asked to "explain," those explanations are to be included on separate sheets of paper. Explanations must include a title that refers to the page and item number, for example: Page GI-2, C.1.a.

A. GENERAL INFORMATION:

1. Site name: _____
2. Reporting period from: _____ To: _____ Days in period: _____
3. Regulatory agency (enter DNR, DCOM, DATCP and/or other): _____
4. DNR issued site number: _____
5. State reimbursement fund claim number and fund name (if not applicable, enter NA): _____
6. Site location:
 - a. DNR region and county: _____
 - b. Street address and municipality: _____
 - c. Township, range, section and quarter quarter section: _____
7. Responsible party:
 - a. Name: _____
 - b. Mailing address: _____

 - c. Phone number: _____
8. Consultant:
 - a. Company name: _____
 - b. Mailing address: _____

 - c. Phone number: _____
9. Contaminants: _____
10. Soil types (USCS or USDA): _____
11. Hydraulic conductivity (cm/sec): _____
12. Average linear velocity of groundwater (ft/yr): _____

**OPERATION, MAINTENANCE, MONITORING
AND OPTIMIZATION REPORTING OF
SOIL AND GROUNDWATER REMEDIATION SYSTEMS**

GENERAL SITE INFORMATION, CONTINUED

SITE NAME AND REPORTING PERIOD:

Site name: _____

Reporting period from: _____ To: _____ Days in period: _____

A. GENERAL INFORMATION (CONTINUED):

13. If soil is treated ex situ, is the treatment location off site? (Y/N) If yes, give location:

a. DNR region and county: _____

b. Township, range, section and quarter quarter section: _____

B. REMEDIATION METHOD: Only submit pages that apply to an individual site. Check all that apply:

- _____ Groundwater extraction (submit a completed page GW-1).
- _____ Free product recovery (submit a completed page GW-1).
- _____ In situ air sparging (submit a completed page GW-2).
- _____ Groundwater natural attenuation (submit a completed page GW-3).
- _____ Other groundwater remediation method (submit a completed page GW-4).
- _____ Soil venting (including soil vapor extraction and bioventing, submit a completed page IS-1).
- _____ Soil natural attenuation (submit a completed page IS-2).
- _____ Other in situ soil remediation method (submit a completed page IS-3).
- _____ Biopiles (submit a completed page ES-1).
- _____ Landspreading/thinspreading of petroleum contaminated soil (submit a completed page ES-2).
- _____ Other ex situ soil remediation method (submit a completed page ES-3).

C. GENERAL EFFECTIVENESS EVALUATION FOR ALL ACTIVE SYSTEMS: If the remediation is active (not natural attenuation), complete this subsection.

1. Is the system operating at design rates and specifications? (Y/N): _____
If the answer is no, explain whether or not modifications are necessary to achieve the goal that was previously established in design.
2. Are modifications to the system warranted to improve effectiveness? (Y/N) If yes, explain: _____
3. Is natural attenuation an effective low cost option at this time? (Y/N): _____
4. Is closure sampling warranted at this time? (Y/N): _____
5. Are there any modifications that can be made to the remediation to improve cost effectiveness? (Y/N) If yes, explain: _____

D. ECONOMIC AND COST DATA TO DATE:

1. Total investigation costs (\$): _____
2. Implementation costs (design, capital and installation costs, excluding investigation costs) (\$): _____
3. Total costs during the previous reporting period (\$): _____
4. Total costs during this reporting period (\$): _____
5. Total anticipated costs for the next reporting period (\$): _____
6. Are any unusual or one-time costs listed in the reporting periods covered by D.3., D.4. or D.5. above? (Y/N) If yes explain: _____
7. If close out is anticipated within 12 months, estimated costs for project closeout (\$): _____

**OPERATION, MAINTENANCE, MONITORING
AND OPTIMIZATION REPORTING OF
SOIL AND GROUNDWATER REMEDIATION SYSTEMS**

GENERAL SITE INFORMATION, CONTINUED

SITE NAME AND REPORTING PERIOD:

Site name: _____

Reporting period from: _____ To: _____ Days in period: _____

E. NAME(S), SIGNATURE(S) AND DATE OF PERSON(S) SUBMITTING FORM: Legibly print name, date and sign. Only persons qualified to submit reports under ch. NR 712 Wis. Adm. Code are to sign this form.

Registered Professional Engineers:

I (print name) _____, hereby certify that I am a registered professional engineer in the State of Wisconsin, registered in accordance with the requirements of ch. A-E 4, Wis. Adm. Code; that this document has been prepared in accordance with the rules of Professional Conduct in ch. A-E 8, Wis. Adm. Code; and that, to the best of my knowledge, all information contained in this document is correct and the document was prepared in compliance with all applicable requirements in chs. NR 700 to 726, Wis. Adm. Code.

Signature, title, P.E. number and date: _____

Hydrogeologists:

I (print name) _____, hereby certify that I am a hydrogeologist as that term is defined in s. NR 712.03(1), Wis. Adm. Code, and that, to the best of my knowledge, all information contained in this document is correct and the document was prepared in compliance with all applicable requirements in chs. NR 700 to 726, Wis. Adm. Code.

Signature, title and date: _____

Scientists:

I (print name) _____, hereby certify that I am a scientist as that term is defined in s. NR 712.03(3), Wis. Adm. Code, and that, to the best of my knowledge, all information contained in this document is correct and the document was prepared in compliance with all applicable requirements in chs. NR 700 to 726, Wis. Adm. Code.

Signature, title and date: _____

Professional Seal(s), if applicable:

**OPERATION, MAINTENANCE, MONITORING
AND OPTIMIZATION REPORTING OF
SOIL AND GROUNDWATER REMEDIATION SYSTEMS**

GROUNDWATER PUMP AND TREAT SYSTEMS AND FREE PRODUCT RECOVERY SYSTEMS

SITE NAME AND REPORTING PERIOD:

Site name: _____

Reporting period from: _____ To: _____ Days in period: _____

Date that the system was first started up: _____

A. GROUNDWATER EXTRACTION SYSTEM OPERATION:

1. Total number of groundwater extraction wells or trenches available and the number in use during period: _____
2. Number of days of operation (only list the number of days the system actually operated, if unknown explain): _____
3. System utilization in percent (days of operation divided by reporting time period multiplied by 100). If < 80%, explain: _____
4. Quantity of groundwater extracted during this time period (gallons): _____
5. Average groundwater extraction rate (gpm): _____
6. Quantity of dissolved phase contaminants removed during this time period in pounds: _____

B. FREE PRODUCT RECOVERY SYSTEM OPERATION:

1. Is free product (nonaqueous phase liquid) being recovered at this site? (Y/N) If yes, list method: _____
2. Quantity of free product extracted during this time period (gallons, enter none if none): _____
3. Average free product extraction rate (gpd): _____

C. SYSTEM EFFECTIVENESS EVALUATION:

1. Is a contaminated groundwater plume fully contained in the capture zone? (Y/N) If no, explain: _____
2. If free product is present, is the free product fully contained in capture zone? (Y/N) If no, explain: _____
3. If free product is present in any wells at the site, but free product was not recovered during reporting period, explain.
4. If free product is not present, determine the single contaminant that requires the greatest percent reduction to achieve ch. NR 140 ES and PAL. Perform this calculation for all contaminants that were present at the site that have ch. NR 140 standards. Use the highest contaminant concentration measured in any sampling points during reporting period. If free product is present, write "FREE PRODUCT" in C.4.a.
 - a. Contaminant: _____
 - b. Percent reduction necessary to reach ch. NR 140 ES and PAL: _____
 - c. Maximum contaminant concentration level in any monitoring well of that contaminant ($\mu\text{g/L}$): _____
 - d. Maximum contaminant concentration level in any extraction well of that contaminant ($\mu\text{g/L}$): _____
 - e. If the maximum concentration in a monitoring well is more that one order of magnitude above the concentration measured in an extraction well, explain why the extracted groundwater contamination levels are significantly less than the levels at other locations within the aquifer.

D. ADDITIONAL ATTACHMENTS: Attach the following to this form:

- Most recent report to the DNR Wastewater Program, if applicable.
- Groundwater contour map with capture zone indicated.
- Groundwater contaminant distribution map (may be combined with contour map).
- Graph of cumulative contaminant removal, if both free product recovery and ground water extraction are used, provide separate graphs.
- Time versus groundwater contaminant concentration graphs for the contaminant listed in C.4.a. (above), as follows:
 - Graph of contaminant concentrations versus time for each extraction well in use during the period.
 - Graph of contaminant concentrations versus time for the monitoring well with the greatest level of contamination.
- Groundwater contaminant chemistry table.
- Groundwater elevations table.
- System operational data table.

**OPERATION, MAINTENANCE, MONITORING
AND OPTIMIZATION REPORTING OF
SOIL AND GROUNDWATER REMEDIATION SYSTEMS**

IN SITU AIR SPARGING SYSTEMS

SITE NAME AND REPORTING PERIOD:

Site name: _____

Reporting period from: _____ To: _____ Days in period: _____

Date that the system was first started up: _____

A. IN SITU AIR SPARGING SYSTEM OPERATION:

1. Number of air injection wells at the site and the number actually in use during the period: _____

2. Number of days of operation (only list the number of days the system actually operated, if unknown explain): _____

3. System utilization in percent (days of operation divided by reporting time period multiplied by 100). If < 80%, explain: _____

B. SYSTEM EFFECTIVENESS EVALUATION:

1. If free product is not present, determine the single contaminant that requires the greatest percent reduction to achieve ch. NR 140 ES and PAL. Perform this calculation for all contaminants that were present at the site that have ch. NR 140 standards. Use the highest contaminant concentration measured in any sampling points during reporting period. If free product is present, write "FREE PRODUCT" in B.1.a.

a. Contaminant: _____

b. Percent reduction necessary to reach ch. NR 140 ES and PAL: _____

c. Maximum contaminant concentration level in any monitoring well ($\mu\text{g/L}$): _____

2. Is there any evidence that air is short circuiting through natural or man-made pathways? (Y/N) If so, explain: _____

3. Is the size of the plume increasing, stabilized, or decreasing (if increasing, explain): _____

C. ADDITIONAL ATTACHMENTS: Attach the following to this form:

- Groundwater contour map.
- Groundwater contaminant distribution map (may be combined with contour map).
- When contaminants are aerobically biodegradable, attach a dissolved oxygen in groundwater map (dissolved oxygen may be combined with the contaminant data on a single map).
- Site map with all air injection wells and groundwater monitoring points.
- Graph of contaminant concentrations versus time for the contaminant listed in B.1.a. (above) for the monitoring point with the greatest level of contamination.
- Groundwater contaminant chemistry table.
- Groundwater elevations table.
- System operational data table.

**OPERATION, MAINTENANCE, MONITORING
AND OPTIMIZATION REPORTING OF
SOIL AND GROUNDWATER REMEDIATION SYSTEMS**

NATURAL ATTENUATION (PASSIVE BIOREMEDIATION) IN GROUNDWATER

SITE NAME AND REPORTING PERIOD:

Site name: _____

Reporting period from: _____ To: _____ Days in period: _____

A. EFFECTIVENESS EVALUATION:

1. If free product is not present, determine the single contaminant that requires the greatest percent reduction to achieve ch. NR 140 ES and PAL. Perform this calculation for all contaminants that were present at the site that have ch. NR 140 standards. Use the highest contaminant concentration measured in any sampling points during reporting period. If free product is present, write "FREE PRODUCT" in A.1.a.

a. Contaminant: _____

b. Percent reduction necessary to reach ch. NR 140 ES and PAL: _____

c. Maximum contaminant concentration level in any monitoring well ($\mu\text{g/L}$): _____

2. Aquifer parameters:

a. Hydraulic conductivity (cm/sec): _____

b. Groundwater average linear velocity (ft/yr): _____

3. Is there a downgradient monitoring well that meets ch. NR 140 standards (Y/N): _____

4. Based on water chemistry results, is the plume expanding, stabilized or contracting: _____

5. If the answer in 4. (above) is "expanding," is natural attenuation still the best option? (Y/N) If yes, explain: _____

6. Biodegradation parameters:

a. Upgradient (or other site specific background) DO level (mg/L): _____

b. DO levels in the part of the plume that is most heavily contaminated (mg/L): _____

7. Is site closure a viable option within 12 months from the date of this form? (Y/N): _____

8. Are there any modifications that can improve cost effectiveness? (Y/N) If yes, explain: _____

9. Have groundwater table fluctuations changed the contaminant level trends over time? (Y/N) If yes, explain: _____

10. Has the direction of ground water flow changed during the reporting period? (Y/N) If yes, approximate change in degrees: _____

B. ADDITIONAL ATTACHMENTS: Attach the following to this form:

- Groundwater contour map.
- Groundwater contaminant distribution map (may be combined with contour map).
- When contaminants are aerobically biodegradable, attach a dissolved oxygen in groundwater map (dissolved oxygen may be combined with the contaminant data on a single map).
- Graph of contaminant concentrations versus time for the contaminant listed in A.1.a. (above) for the monitoring point with the greatest level of contamination.
- Graph of contaminant concentrations versus distance.
- Groundwater contaminant chemistry table.
- Groundwater biological parameters.
- Groundwater elevations table.

**OPERATION, MAINTENANCE, MONITORING
AND OPTIMIZATION REPORTING OF
SOIL AND GROUNDWATER REMEDIATION SYSTEMS**

OTHER GROUNDWATER REMEDIATION METHODS

SITE NAME AND REPORTING PERIOD:

Site name: _____

Reporting period from: _____ To: _____ Days in period: _____

Date that the system was first started up: _____

A. EFFECTIVENESS EVALUATION:

1. If free product is not present, determine the single contaminant that requires the greatest percent reduction to achieve ch. NR 140 ES and PAL. Perform this calculation for all contaminants that were present at the site that have ch. NR 140 standards. Use the highest contaminant concentration measured in any sampling points during reporting period. If free product is present, write "FREE PRODUCT" in A.1.a.

a. Contaminant: _____

b. Percent reduction necessary: _____

c. Maximum contaminant concentration level in any monitoring well ($\mu\text{g/L}$): _____

2. Is the size of the plume increasing, stabilized, or decreasing: _____

3. Describe the method used to remediate groundwater at the site. _____

4. List any additional information required by the DNR for this method for this site:

B. ADDITIONAL ATTACHMENTS: Attach the following to this form:

- Groundwater contour map.
- Groundwater contaminant distribution map (may be combined with contour map).
- When contaminants are aerobically biodegradable, attach a dissolved oxygen in groundwater map (dissolved oxygen may be combined with the contaminant data on a single map).
- Graph of contaminant concentrations versus time for the contaminant listed in A.1.a. (above) for the monitoring point with the greatest level of contamination.
- Groundwater contaminant chemistry table.
- Groundwater elevations table.
- Any other attachments required by the DNR for this remediation method.

**OPERATION, MAINTENANCE, MONITORING
AND OPTIMIZATION REPORTING OF
SOIL AND GROUNDWATER REMEDIATION SYSTEMS**

SOIL VENTING (INCLUDING BOTH SOIL VAPOR EXTRACTION AND BIOVENTING)

SITE NAME AND REPORTING PERIOD:

Site name: _____

Reporting period from: _____ To: _____ Days in period: _____

Date that the system was first started up: _____

A. SOIL VENTING SYSTEM OPERATION:

1. Number of air extraction wells available and number of wells actually in use during the period: _____

2. Number of days of operation (only list the number of days the system actually operated, if unknown explain): _____

3. System utilization in percent (days of operation divided by reporting time period multiplied by 100). If less than 80%, explain: _____

4. Average depth to groundwater: _____

B. EFFECTIVENESS EVALUATION:

1. Average contaminant removal rate for the entire system (pounds per day): _____

2. Average contaminant removal rate per well (pounds per day): _____

3. If the average contaminant removal rate is less than one pound per day for the entire system, or if the average contaminant removal rate per well is less than one tenth of a pound per day, evaluate the following:

a. If contaminants are aerobically biodegradable and confirmation borings have not been drilled in the past year:

i. Oxygen levels in extracted air (percent): _____

ii. Methane levels in extracted air (ppm_v) If over 10 ppm_v, explain: _____

iii. If methane is not present above 10 ppm_v and if oxygen is greater than 20 percent in extracted air, you should either:

- Drill confirmation borings during the next reporting period, if the entire site should be considered for closure.
- Or, perform an in situ respirometry test in a zone of high contamination. Do not perform the test in an air extraction well, use a gas probe or water table well. If a zero order rate of decay based on oxygen depletion is less than 2 mg/kg per day, then you should drill confirmation borings, if the entire site should be considered for closure. If the rate of decay is between 2 and 10 mg/kg, operate for one more reporting period before evaluating further. If the zero order rate of decay is greater than 10 mg/kg total hydrocarbons, continue operating the system in a manner than maximizes aerobic biodegradation.

b. If contaminants are not aerobically biodegradable and confirmation borings have not been recently drilled during the past year, you should drill confirmation borings during the next reporting period if the entire site should be considered for closure.

c. If soil borings were drilled during the past year and soil contamination remains above acceptable levels, explain if the system effectiveness can be increased and/or if other options need to be considered to achieve cleanup criteria.

C. ADDITIONAL ATTACHMENTS: Attach the following to this form:

- Well and soil sample location map indicating all air extraction wells. If forced air injection wells are also in use, identify those wells.
- If water table monitoring wells are present at the site, a map of well locations.
- Time versus vapor phase contaminant concentration graph.
- Time versus cumulative contaminant removal graph.
- Groundwater elevations table, if water table wells are present at the site; also list screen lengths and elevations.
- Table of soil contaminant chemistry data.
- Soil gas data, if gas probes are used to monitor subsurface conditions in locations other than where air is extracted.
- System operational data table.

**OPERATION, MAINTENANCE, MONITORING
AND OPTIMIZATION REPORTING OF
SOIL AND GROUNDWATER REMEDIATION SYSTEMS**

NATURAL ATTENUATION (PASSIVE BIOREMEDIATION) IN SOIL

SITE NAME AND REPORTING PERIOD:

Site name: _____

Reporting period from: _____ To: _____ Days in period: _____

A. EFFECTIVENESS EVALUATION:

1. Soil gas information in the soil that is most contaminated from a permanently installed gas probe(s) or water table monitoring well(s).

a. Hydrocarbon levels (ppm_v with an FID): _____

b. Oxygen levels (percent): _____

c. Carbon dioxide levels (specify ppm_v or percent): _____

d. Methane levels (ppm_v): _____

2. Soil gas information in background (uncontaminated soil) from permanently installed gas probe(s) or water table monitoring well(s):

a. Hydrocarbon levels (ppm_v with an FID): _____

b. Oxygen levels (percent): _____

c. Carbon dioxide levels (specify ppm_v or percent): _____

d. Methane levels (ppm_v): _____

3. List the results of the single boring that had the highest levels of soil contamination during the last round of soil sampling, and the date those samples were collected. Since soil borings are only drilled periodically, list the most recent data even if the data is prior to this reporting period. Since this data is used to assess progress based on the most recent soil sampling event, do not list data from prior sampling events.

a. Total hydrocarbons. Specify if GRO and/or DRO. (mg/kg): _____

b. Specific compounds (µg/kg):

i. Benzene: _____

ii. 1,2 Dichloroethane: _____

iii. Ethylbenzene: _____

iv. Toluene: _____

v. Total xylenes: _____

4. Is there any evidence that contaminants are leaching into groundwater? (Y/N): _____
If the answer is yes and if groundwater quality is not being monitored, explain.

5. Is site closure a viable option within 12 months from the date of this form? (Y/N): _____

6. Are there any modifications that can be made to the remediation to improve cost effectiveness? (Y/N) If yes, explain: _____

B. ADDITIONAL ATTACHMENTS: Attach the following to this form:

- Well and soil sample location map.
- Cross sections showing the water table, soil sampling locations, screened intervals for gas probes or water table wells, geologic contacts, and any former excavation boundaries.
- Graphs of contaminant concentrations, oxygen, carbon dioxide and methane levels over time.
- Groundwater elevations table, if water table wells are present at the site.
- Table of soil contaminant chemistry.
- Table of soil gas readings.

**OPERATION, MAINTENANCE, MONITORING
AND OPTIMIZATION REPORTING OF
SOIL AND GROUNDWATER REMEDIATION SYSTEMS**

OTHER IN SITU SOIL REMEDIATION METHODS

SITE NAME AND REPORTING PERIOD:

Site name: _____

Reporting period from: _____ To: _____ Days in period: _____

Date that the system was first started up: _____

A. EFFECTIVENESS EVALUATION:

1. Describe the method used to remediate soil at the site. _____

2. List all information required by the DNR for this remediation method for this site:

B. ADDITIONAL ATTACHMENTS: Attach the following to this form:

- Any other attachments required by the DNR for this remediation method.

**OPERATION, MAINTENANCE, MONITORING
AND OPTIMIZATION REPORTING OF
SOIL AND GROUNDWATER REMEDIATION SYSTEMS**

EX SITU SOIL TREATMENT USING BIOPILES

SITE NAME AND REPORTING PERIOD:

Site name: _____

Reporting period from: _____ To: _____ Days in period: _____

Date that the system was first started up: _____

A. EFFECTIVENESS EVALUATION:

1. Volume of soil in the biopile (if multiple biopiles, list number of piles and total volume): _____

2. Monitoring used to assess progress and verify optimal conditions for biodegradation.

a. Vapor phase measurements of gases (average of all readings from most recent sampling event):

i. VOCs by FID (ppm_v): _____

ii. Oxygen (percent): _____

iii. Carbon dioxide (percent): _____

iv. Methane (ppm_v): _____

b. Soil temperature (°F): _____

c. Soil moisture sensors, if used (percent): _____

3. Treatment amendments added to the soil during construction:

a. Artificial nutrients, excluding manure.

i. Type(s) and total pounds added: _____

ii. Nitrogen and phosphorous content of the added amendment (percent): _____

b. Manure (total pounds): _____

c. Natural organic materials (straw, wood chips, etc.) (type and total pounds): _____

4. Forced air biopiles only answer the following:

a. Total air flow rate of the ventilation system (scfm): _____

b. Average contaminant removal rate (pounds per day): _____

c. Average biodegradation rate based on oxygen utilization (pounds per day): _____

5. If soil samples have been taken to monitor progress, list results. Only list the most recent results. If none collected enter NA.

a. Total hydrocarbons. Specify if GRO and/or DRO. (mg/kg): _____

b. Specific compounds (µg/kg):

i. Benzene: _____

ii. 1,2 Dichloroethane: _____

iii. Ethylbenzene: _____

iv. Toluene: _____

v. Total xylenes: _____

B. ADDITIONAL ATTACHMENTS: Attach the following to this form:

- Figure showing the construction details of the biopile and any sampling locations within the biopile.
- Table of soil contaminant chemistry data.
- Table of operational data.

**OPERATION, MAINTENANCE, MONITORING
AND OPTIMIZATION REPORTING OF
SOIL AND GROUNDWATER REMEDIATION SYSTEMS**

EX SITU SOIL TREATMENT USING LANDSPREADING/THINSPREADING

SITE NAME AND REPORTING PERIOD:

Site name: _____

Reporting period from: _____ To: _____ Days in period: _____

Date that soil was landspread/thinspread: _____

A. EFFECTIVENESS EVALUATION:

1. Method used (landspreading or thinspreading): _____

Note: For purposes of this form, "landspreading" is the placement of contaminated soil on native topsoil, incorporation of that soil into the native soil and planting crops or other plants on it. The term "thinspreading" refers to placing contaminated soil on an impervious base for aeration.

2. Was any progress monitoring using field screening on soil conducted during this reporting period? (Y/N): _____

3. If the answer to A.2. (above) is yes:

i. List monitoring method: _____

ii. List monitoring results: _____

4. Is there any evidence of soil erosion at the landspreading/thinspreading location? (Y/N): _____

5. Spreading thickness (inches): _____

6. Type of crop planted (if thinspreading with no crop planted, so state): _____

7. Anticipated confirmation sampling date: _____

8. Soil sample results, if soil samples for laboratory analysis have been collected to monitor progress. Only list the highest result of the most recent sampling round. If no samples have been collected, enter NA.

a. Total hydrocarbons. Specify if GRO and/or DRO. (mg/kg): _____

b. Specific compounds (µg/kg):

i. Benzene: _____

ii. 1,2 Dichloroethane: _____

iii. Ethylbenzene: _____

iv. Toluene: _____

v. Total xylenes: _____

B. ADDITIONAL ATTACHMENTS: Attach the following to this form:

- Map of the landspreading/thinspreading area. If soil samples have been collected, specify locations of samples and dates of sampling.
- Table of soil contaminant chemistry data.
- Table of any field screening results with dates of sample collection.

**OPERATION, MAINTENANCE, MONITORING
AND OPTIMIZATION REPORTING OF
SOIL AND GROUNDWATER REMEDIATION SYSTEMS**

OTHER EX SITU SOIL REMEDIATION METHODS

SITE NAME AND REPORTING PERIOD:

Site name: _____

Reporting period from: _____ To: _____ Days in period: _____

Date that the system was first started up: _____

A. EFFECTIVENESS EVALUATION:

1. Describe the method used to remediate soil at the site. _____

2. List all information required by the DNR for this remediation method for this site:

B. ADDITIONAL ATTACHMENTS: Attach the following to this form:

- Any other attachments required by the DNR for this remediation method.

**OPERATION, MAINTENANCE, MONITORING
AND OPTIMIZATION REPORTING OF
SOIL AND GROUNDWATER REMEDIATION SYSTEMS**

INSTRUCTIONS AND INFORMATION.

Specific Page by Page Instructions for This Form. The site name and reporting period is listed on every page. Then if the pages are inadvertently separated, that information can be used to determine which pages form the report.

When the form specifies that the person filling in the form "explain," those explanations are to be included on separate sheets of paper. Explanations must include a title that refers to the page and item, for example: Page GI-2, C.1.a.

Page GI-1, General Site Information.

- A.1. List the name as it appears on the DNR tracking system. If the person filling out the form does not know what the name on the tracking system is, use the name that the DNR used in the most recent correspondence.
- A.2. The reporting period should be either from January 1 to June 30 or July 1 to December 31 for active systems. For passive systems, use a calendar year basis. If however the report covers a newly installed system, list the actual startup date instead of January 1 or July 1. For new passive systems, use the first date that monitoring data is available as the date of startup.
- A.3. Enter all regulatory agencies that regulate the site.
- A.4. This form is a DNR form. For that reason, list the DNR site number. If there are other agencies regulating the site, listing identification numbers for other agencies is also recommended, but not mandatory, unless specified by those other agencies.
- A.5. Some sites are eligible for reimbursement from one or more state agencies. List all agencies that will be asked to reimburse costs on this site and the claim numbers issued by those agencies.
- A.6. If the information listed for the site location is not sufficient information for a person to use to drive to a site (example: no street address in a rural area), also include a map that is sufficient for a person to use to drive to the site. A U.S.G.S. topographic map that shows the site location may be used.
- A.7. Self explanatory.
- A.8. Self explanatory.
- A.9. List the contaminants that have at one time exceeded the PALs or Table Values in ch. NR 720. If GRO and/or DRO exceed the ch. NR 720 standards, also list GRO and/or DRO. Do not list other contaminants that have never exceeded state standards at the site. If more room is necessary, write "SEE ATTACHED SHEETS" and list all contaminants on a separate sheet.
- A.10. List the predominant soil types that are contaminated. If there is both contaminated soil and groundwater at the site, list soil types both above and below the water table. If only some soil is contaminated, do not list the soil types that are uncontaminated. If the site soils meet soil cleanup criteria, but groundwater is contaminated, so state that. Specify if the USCS or USDA system is used for soil descriptions. This line specifies soil because the vast majority of contaminated sites do not have contaminated bedrock. If bedrock is contaminated, also list that bedrock type.
- A.11. If the groundwater meets ch. NR 140 standards, enter "NA - NO NR 140 EXCEEDANCES". Otherwise, list the estimated hydraulic conductivity and the method used to estimate it (bail-down tests, calculations based on grain size, pumping test, etc.) If the hydraulic conductivity has not been determined, state when the tests are to be conducted. When a number of test results are available, list the range of results and the geometric mean. If however some results have a low level of accuracy and some results have a high level of accuracy, you should only list the most accurate results. See the Section on aquifer testing in the *Guidance on Design, Installation and Operation of Ground Water Extraction and Product Recovery Systems* for more information.
- A.12. If the groundwater meets ch. NR 140 standards, enter "NA - NO NR 140 EXCEEDANCES". Otherwise, enter groundwater average linear velocity as a function of hydraulic conductivity, effective porosity and the groundwater gradient. You should use the geometric mean from A.11. (above) and the most representative value for the gradient at the site. Estimate the effective porosity based on soil types and geologic origin of the soil. If there are reasons to believe that the average liner velocity estimate is less than the actual rate at the site, so state that reason. Secondary porosity effects, flow through submerged utility trenches, widespread contaminant distribution in low permeability soils, etc., are reasons to assume that the actual migration rate is much greater than the predicted average linear velocity. In such cases, you should explain the reasoning for doubting the predicted average linear velocity.

Page GI-2, General Site Information Continued.

List site name as shown on page GI-1 and the reporting period.

- A.13. If the information listed for the soil treatment location is not sufficient information for a person to use to drive to a site, also include a map that is sufficient for a person to use to drive to the site. A U.S.G.S. topographic map or a plat map that shows the site location may be used.

**OPERATION, MAINTENANCE, MONITORING
AND OPTIMIZATION REPORTING OF
SOIL AND GROUNDWATER REMEDIATION SYSTEMS**

Page GI-2, General Site Information Continued.

- B. Check all methods used at a site. For example, if groundwater extraction, free product recovery and soil venting are used, check all three methods and submit the additional pages for those methods. If dual-phase or bioslurping are used, these methods extract both air and groundwater, check boxes for and attach additional pages for both soil venting and pump and treat.
- C. Remediation systems that use any form of enhancement are considered "active" and sites where there are no enhancements of any kind are considered "passive" forms of remediation. For purposes of these forms, natural attenuation (also called naturally occurring bioremediation) is "passive" and all other remediation methods are "active" methods.
- C.1. Design flow rates refers to flow rates such as gallons per minute extracted by a ground water extraction system, standard cubic feet per minute extracted by a soil venting system, standard cubic feet per minute injected by an in situ air sparging system, etc. If the actual flow rate is within 80 percent of the rate predicted in the design, consider that as meeting the design specification.
- C.2. Self explanatory.
- C.3. Self explanatory.
- C.4. Self explanatory.
- C.5. Self explanatory.
- D. The cost data in this section is used by DNR staff to evaluate whether or not the selected remedy is the most cost effective remedy and whether or not system modifications may be warranted to improve efficiency and/or cost effectiveness. Responsible parties and consultants are encouraged to submit cost information so that DNR staff may assist responsible parties and consultants accomplish environmental cleanups in the most cost effective manner.

Total costs for past costs are all costs to date. This information is for all costs that were incurred to investigate and/or remediate the site. These costs include but are not limited to: consulting labor and supplies, laboratory testing, transportation, equipment, etc. If the consultant does not pass all costs through the consulting firm, the consultant will need to contact their client for other non-consulting costs to determine total costs. Exceptions include costs for attorney fees, accounting, claim assistance in preparing claims to state reimbursement funds, or other indirect expenses that are not essential to remediating the site.

- D.1. Self explanatory.
- D.2. The initial implementation costs are all costs that are incurred to start implementing a remedy at a site. Costs for the investigation however are excluded because those costs are incurred prior to remedy selection. Since costs for treatability and/or pilot testing are used to procure data for remedial design and are specific to different remediation methods, these costs should be included in implementation costs and not investigation costs. Startup or shakedown costs are also considered implementation costs and should not be considered operation and maintenance costs.
- D.3. Costs for implementation or investigation should not be repeated here or they will be double counted.
- D.4. Costs for implementation or investigation should not be repeated here or they will be double counted.
- D.5. Costs for implementation or investigation should not be repeated here or they will be double counted.
- D.6. Examples of one-time or unusual costs include the following:
 - Replacing a burned out motor on a pump.
 - Replacement of a well that was destroyed by a snowplow.
 - Confirmation sampling to determine if the site meets closeout criteria. This type of cost is considered an unusual cost because this type of sampling is not conducted during most reporting periods.
- D.7. This estimate of costs is for all costs to close out a site minus the salvage value of any remediation equipment. Pertinent costs include items such as well abandonment, equipment removal from the site, consulting costs associated with these items, etc. Do not include any costs that will not be paid by a state reimbursement fund, such as repaving.

Page GI-3, General Site Information Continued.

- E. Self explanatory.

Page GW-1, Groundwater Extraction and Product Recovery.

List site name as shown on page GI-1 and the reporting period.

- A.1. List two numbers, the total number of extraction wells at the site and the number that were in actual use during the period. If all wells were in use, state that on the form.
- A.2. The number of days of operation are the number of days that the system was actually operated. If the system was shut down for reasons such as: repairs were necessary, piping froze, shut down to provide time for subsurface conditions to equilibrate before sampling, etc., do not list those days as being in operation.
- A.3. System utilization is a measure of the amount of time that the system operated relative to the amount of time that it could have operated.

**OPERATION, MAINTENANCE, MONITORING
AND OPTIMIZATION REPORTING OF
SOIL AND GROUNDWATER REMEDIATION SYSTEMS**

Page GW-1, Groundwater Extraction and Product Recovery (Continued).

- A.4. Self explanatory.
- A.5. The average is for the entire site, not per well or trench. For purposes of determining the average ground water extraction rate, calculate the average based on the total volume of groundwater extracted divided by the time of the reporting period. For example, if the system operated at 10 gallons per minute for one month, the amount of water extracted would be approximately 432,000 gallons. If the reporting period was six months long, then the time period is approximately 260,000 minutes. Therefore, the average flow rate over six months is 432,000 divided by 260,000 minutes for an average flow rate of 1.67 gallons per minute (gpm).
- A.6. Calculate the total dissolved contaminants removed in pounds. If the estimate is a sum of BTEX and not based on a total hydrocarbon test (GRO and/or DRO), so state that on the form.

- B.1. Self explanatory.
- B.2. Self explanatory.
- B.3. The average should be based on the entire site over the entire reporting period. See instructions above for A.5. List the free product recovery rate as gallons per day (gpd), not gallons per minute (gpm).

- C.1. To answer this question, a thorough evaluation of water levels and chemical analyses in all monitoring points at the site is necessary.
- C.2. If the capture zone has not been determined mathematically, it will need to be determined to answer this question. See the *Guidance on Design, Installation and Operation of Ground Water Extraction and Product Recovery Systems* for and any recent update or errata sheets for more information on plume capture.
- C.3. Self explanatory.
- C.4. When free product is present, line C.4.a. should state "FREE PRODUCT" and lines C.4.b. through C.4.d. are left blank. Otherwise, complete the following calculations.
There typically are several compounds at most contaminated sites that exceed the standards in ch. NR 140. The purpose of this question is to focus on the single contaminant that requires the most treatment to achieve groundwater quality standards on a percent reduction basis. For example, the most recent round of sampling at an example site demonstrated the highest levels of contaminants were 1,000 µg/L benzene and 1,000 µg/L toluene in the most heavily contaminated monitoring well. The ES and PAL for benzene is 5 µg/L and 0.5 µg/L (respectively) and for toluene the ES and PAL is 343 µg/L and 68.6 µg/L (ES and PAL data as of August 1995). Therefore the percent reduction to meet the ES and PAL for benzene is 99.5 and 99.95 percent and for toluene it is 65.7 and 93.14 percent. For that reason, the single contaminant that is most critical to reaching state groundwater standards is benzene. Therefore benzene is entered on line a. In this example, 99.5 and 99.95 percent is entered on line b. In this example, 1,000 µg/L is entered on line c. In this example, benzene is the driving factor, therefore enter the maximum benzene level in the single most heavily contaminated extraction well during the most recent sampling period on line d.

- D. See the generic discussion at the end of the instructions (below) for figures, graphs and tables, starting on page INS-7.

Page GW-2, In Situ Air Sparging.

List site name as shown on page GI-1 and the reporting period.

- A.1. Self explanatory.
- A.2. Self explanatory.
- A.3. Self explanatory.

- B.1. See instructions for Page GW-1, Item C.4.
- B.2. Self explanatory.
- B.3. Self explanatory.

- C. See the generic discussion at the end of the instructions (below) for figures, graphs and tables, starting on page INS-7.

Page GW-3, Natural Attenuation in Groundwater.

List site name as shown on page GI-1 and the reporting period.

- A.1. See instructions for page GW-1, Item C.4.
- A.2.a. List the estimated hydraulic conductivity that was listed on line A.11 on page GI-1.
- A.2.b. List the groundwater average linear velocity that was listed on line A.12 on page GI-1.
- A.3. Assess the monitoring well network to determine if there is a down gradient well that has not been impacted by the contaminants. Consider the possibility of a submerged (or diving) plume in that assessment. If all evidence indicates that the plume does not extend to the farthest "clean" downgradient well, indicate "YES" on the form. Otherwise indicate "NO" on the form. If there are not plans to install such a well, explain.

**OPERATION, MAINTENANCE, MONITORING
AND OPTIMIZATION REPORTING OF
SOIL AND GROUNDWATER REMEDIATION SYSTEMS**

Page GW-3, Natural Attenuation in Groundwater (Continued).

- A.4. Based on the contaminant distribution, evaluate whether or not the plume is expanding, stabilized, or contracting. When making this determination, consider the contaminant that requires the greatest percent reduction to achieve ch. NR 140 standards.
- A.5. If the plume is expanding and a justification is necessary, add additional sheets justifying why natural attenuation is still the appropriate remedy. If it is not, further describe in the explanation the plans to use a different remedy.
- A.6.a. Enter the upgradient dissolved oxygen (DO) level(s). If however there are contaminants measured in the upgradient well, it is not a true background measurement. In that case enter "UNKNOWN" on the form.
- A.6.b. Enter the range of DO values measured in wells within the plume.
- A.7. Self explanatory.
- A.8. Self explanatory.
- A.9. Self explanatory.
- A.10. Self explanatory.
- B. See the generic discussion at the end of the instructions (below) for figures, graphs and tables, starting on page INS-7.

Page GW-4, Other Groundwater Remediation Methods.

List site name as shown on page GI-1 and the reporting period.

- A.1. See instructions for page GW-1, Item C.4.
- A.2. Self explanatory.
- A.3-4. Enter the information specified by the DNR for this method at this site.

Page IS-1, Soil Venting (Including both Soil Vapor Extraction and Bioventing).

List site name as shown on page GI-1 and the reporting period.

- A.1. Self explanatory.
- A.2. Self explanatory.
- A.3. Self explanatory.
- B.1. Self explanatory.
- B.2. Self explanatory.
- B.3. This subsection is used as a trigger for determining if the system requires an evaluation for future activities, such as improvements, converting the site to monitoring for natural attenuation, closure, etc. If an in situ respiration test must be performed, see Hinchee, R.E. and Ong, S.K. 1992. A Rapid In Situ Respiration Test for Measuring Aerobic Biodegradation Rates of Hydrocarbons in Soil. *Journal of the Air and Waste Management Association*. Volume 42, Number 10. Pages 1305 to 1312 for general procedures. For a discussion of methane monitoring, see the instructions for page IS-2, item A.1.d., below. If the contaminant extraction rate in B.3. is greater than the trigger levels, leave lines B.3.a.i. and B.3.a.ii. blank.
- C. See the generic discussion at the end of the instructions (below) for figures, graphs and tables, starting on page INS-7.

Page IS-2, Natural Attenuation in Soil.

List site name as shown on page GI-1 and the reporting period.

- A.1. This data is used to assess subsurface conditions based on soil gas data. Whenever possible, a permanently installed gas probe should be used. If at all possible, the gas probe should be located in the part of the site that is most heavily contaminated, since that is the part of the site that is likely to take the longest amount of time to meet ch. NR 720 standards. Water table wells that have screen exposed above the water table are also good measuring points. When installing permanent gas probes, you should install the screen deep enough that a true measure of the most heavily contaminated soil is possible, but install the screen shallow enough to assure that it is not submerged by groundwater table fluctuations. In some situations where the depth of contamination is variable, consideration should be given to using nested gas probes instead of only using probes at a single depth. Measuring points that should not be used include temporary gas probes because these points are less repeatable from one monitoring event to the next. Also, if there has been an active soil venting system in use at the site, the air extraction wells should not be used because these wells are in locations that have had much more aggressive treatment than the rest of the site.
- A.1.a. A flame ionization detector (FID) is specified instead of a photo ionization detector (PID) because PIDs often read inaccurately in moist oxygen deficient/carbon dioxide rich atmospheres. Also, PIDs do not detect some petroleum compounds.
- A.1.b. Self explanatory.

**OPERATION, MAINTENANCE, MONITORING
AND OPTIMIZATION REPORTING OF
SOIL AND GROUNDWATER REMEDIATION SYSTEMS**

Page IS-2, Natural Attenuation in Soil (Continued).

- A.1.c. Self explanatory.
- A.1.d. Methane readings are used to measure for anaerobic conditions. When the original product that is lost is a refined petroleum product (not crude oil), there should not be any methane within the product. Methane however may be produced under very anaerobic conditions. Any method may be used for measuring methane provided that the detection limit is less than a few ppm_v. One convenient method is to use an FID that is equipped with a granular activated carbon filter to filter out non-methane components. Some instrument manufacturers make these filters available as options. In some cases an FID will flame out due to an oxygen deficiency. Some instrument manufacturers offer a dilution device as an accessory that is designed to prevent flameouts and also raises the upper limit of measurement to 10,000 ppm_v or higher. If the meter "pegs" at 10,000 ppm_v (or one percent), enter ">10,000 ppm_v."
- A.2. The background monitoring point is predominantly used to measure natural oxygen and carbon dioxide levels in soil over time. For this reason, the background monitoring point should be reasonably close to the site, but not so close that the conditions are no longer representative. Considerable variations over time can occur, this background point should be measured during every sample event. Considerations for determining if a background point is representative include:
 - If an on-site background point has minor levels of VOCs in it due to gas phase diffusion, that is acceptable, but if the levels are high, it may not be representative of true background conditions.
 - Background oxygen and carbon dioxide levels vary with soil type and natural organic carbon content. For this reason, if at all possible, the soil types should be identical within the screened interval of all gas probes.
 - The same depths should be used for all gas probes to allow comparison from one location to the next. If the depth to water varies greatly across the site, a certain amount of confusion in the data is likely. In this case, use professional judgement to provide the best data possible at a reasonable cost.
- A.3. Enter this data for petroleum fuel sites. For other sites, provide the data that is most appropriate for the situation.
- A.4. Self explanatory.
- A.5. Self explanatory.
- A.6. Self explanatory.
- B. Cross sections are self explanatory, see the generic discussion at the end of the instructions (below) for other attachments.

Page IS-3, Other In Situ Soil Treatment Methods.

List site name as shown on page GI-1 and the reporting period.

- A.1. Self explanatory.
- A.2. Enter the information specified by the DNR for this method at this site.

Page ES-1, Ex Situ Soil Treatment Using Biopiles.

List site name as shown on page GI-1 and the reporting period.

- A.1. Self explanatory.
- A.2. Self explanatory.
- A.3.a. The term "artificial nutrients" essentially means agricultural fertilizers or any other fertilizer products.
- A.3.a.i. The types of fertilizers that are added should be listed here by chemical names, not by vendor trade names.
- A.3.a.ii. List nitrogen content as N, list phosphorous content as phosphoric acid (P₂O₅). Note: Fertilizer ratings are based not on actual content of N, P and K, but on nitrogen (as N), phosphorous (as P₂O₅) and potassium (as K₂O).
- A.3.b. Self explanatory.
- A.3.c. Self explanatory.
- A.4.a. Self explanatory.
- A.4.b. Self explanatory.
- A.4.c. See example calculations at the end of this set of instructions.
- A.5. Enter this data for petroleum fuel sites. For other sites, provide the data that is most appropriate for the situation.
- B. The figure is self explanatory. See the generic discussion at the end of the instructions (below) for instructions for the tables.

**OPERATION, MAINTENANCE, MONITORING
AND OPTIMIZATION REPORTING OF
SOIL AND GROUNDWATER REMEDIATION SYSTEMS**

Page ES-2, Ex Situ Soil Treatment Using Landspreading/Thinspreading.

List site name as shown on page GI-1 and the reporting period.

- A.1. Self explanatory.
- A.2. Self explanatory.
- A.3. Self explanatory.
- A.4. Self explanatory.
- A.5. Self explanatory.
- A.6. Self explanatory.
- A.7. Self explanatory.
- B. A map to scale of the landspreading location including and landmarks or benchmarks. When samples have been collected, the distances to any landmarks or benchmarks should be indicated.

Page ES-3, Other Ex Situ Soil Treatment Methods.

List site name as shown on page GI-1 and the reporting period.

- A.1. Self explanatory.
- A.2. Enter the information specified by the DNR for this method at this site.

**OPERATION, MAINTENANCE, MONITORING
AND OPTIMIZATION REPORTING OF
SOIL AND GROUNDWATER REMEDIATION SYSTEMS**

Figures, Graphs and Tables. When figures and graphs are specified, they should at a minimum contain the following information, or an explanation as to why the information is not necessary.

Maps. All maps should include the applicable information specified in s. NR 724.11(6), Wis. Adm. Code. In most cases, all information can be combined into a single map. There are times that a single map will have so much data that it is essentially unreadable. The consultant should use professional judgement when determining if a single map or multiple maps best portray the information necessary.

• Groundwater Contour Map Guidelines.

- List groundwater elevations for each measuring point on the map.
- Use the most recent data available.
- For water table maps, do not use data from deeper piezometers. If piezometer data is shown, use a different symbol for the piezometers than used for water table wells.
- If any wells are dry, indicate that on the map.
- If free product is present at site, shade the area where free product is estimated to be present.
- If groundwater is extracted with a pump and treat system, also denote plume capture zone.
- If in situ air sparging or soil venting is in use, specify on the map if the system was operating or shut down during the water level measurements. See the Subsection on water table maps in the *Guidance on Design, Installation and Operation of Ground Water Extraction and Product Recovery Systems* for more information on this topic.

• Groundwater Contaminant Distribution Map Guidelines.

- Only contaminants that exceed the ch. NR 140 ES or PAL should be shown on the map. When contaminants are above the PAL or ES at some data points and below the PAL or ES at other data points, list the data for all locations to portray which areas of the site meet ch. NR 140 groundwater quality standards.
- If a well is not sampled due to the presence of free product indicate "FREE PRODUCT" at those data points.
- If more than five contaminants exceed ch. NR 140 ES, only the five contaminants that require the greatest percent reduction to achieve ch. NR 140 ES or PAL should be shown on the map.
- Drawing isoconcentration lines is optional, unless specified for the site on a site specific basis.
- If the contamination has crossed the property line, that property line should be clearly denoted on the map.
- If in situ air sparging is used, water samples from ch. NR 141 type monitoring wells may not represent aquifer water quality as a whole. For that reason, groundwater data should be obtained from driven probes with no filter pack. If there are no driven probes and conventional ch. NR 141 monitoring wells are used, shut down the air injection system at least two weeks prior to collecting groundwater samples. See the *Guidance on Design, Installation and Operation of In Situ Air Sparging Systems* and the August 1995 update sheets for more information on this topic.

• Dissolved Oxygen Map Guidelines.

- Dissolved oxygen data may be shown on the contaminant concentration graphs or on a separate graph.
- Dissolved oxygen maps are optional for ground water extraction and product recovery systems.
- When in situ air sparging is used, monitoring points may not represent aquifer water quality as a whole. For that reason, groundwater data should be obtained from driven probes with no filter pack. If there are no driven probes and conventional ch. NR 141 monitoring wells are used, shut down the air injection system at least two weeks prior to collecting groundwater samples for DO. See the *Guidance on Design, Installation and Operation of In Situ Air Sparging Systems* and the August 1995 update sheets for more information on this topic.

• Well and Soil Sample Location Map Guidelines. Well and sample location maps for all methods should clearly indicate the location(s) of the release or the area where soil contamination historically has been highest. Also, if part of the contamination has been excavated, the pit boundaries.

The recommended documentation for each remedial method is as follows:

- Groundwater Extraction and Product Recovery - separate well location maps should not be provided, instead the wells should be indicated on the groundwater contour and contaminant distribution maps.
- In Situ Air Sparging - the map should indicate all air injection wells, soil venting extraction wells, and all groundwater monitoring points.
- Natural Attenuation in Groundwater - separate well location maps should not be provided, instead the wells should be indicated on the groundwater contour maps.
- Soil Venting - indicate all air extraction wells. If any gas probes are used to assess subsurface conditions in either contaminated zones or background locations, also indicate those data points with a different symbol. If soil samples have been collected recently to track progress, indicate those locations with the date of sampling noted on the map.
- Natural Attenuation in Soil - show all monitoring points. Indicate which data points are background measuring points. If soil samples have been collected recently to track progress, indicate those locations with the date of sampling noted on the map. If the site was previously treated by soil venting, the locations of former air extraction wells should also be shown since these are areas where aggressive treatment has been applied. Also show area(s) of paved and unpaved ground surface. If pavement is significantly broken to allow significant water infiltration and air diffusion, map that area as broken pavement.

**OPERATION, MAINTENANCE, MONITORING
AND OPTIMIZATION REPORTING OF
SOIL AND GROUNDWATER REMEDIATION SYSTEMS**

Graphs. All graphs that show time versus contaminant concentration or cumulative contaminant removal should be based on total time, not only operation time. All graphs that denote cumulative removal should use pounds of contaminant removed. Graphs should accurately show the time period(s) when the system was not operating. Plot time on the X axis, concentration or cumulative removal data on the Y axis.

- Time Versus Cumulative Removal. The recommended documentation for each remedial method is as follows:
 - Groundwater Extraction and Product Recovery - separate graphs should be used for free product recovery and dissolved phase recovery. A single graph for each phase is adequate, per well graphs are only necessary when specified by the Department on a site specific basis.
 - In Situ Air Sparging - no graph is necessary (removal data is shown on the graphs for the soil venting system).
 - Natural Attenuation in Groundwater - no graph is necessary.
 - Soil Venting - provide a graph of cumulative removal for total VOCs for the total system.
 - Natural Attenuation in Soil - no graph is necessary.
 - Ex Situ Soil Treatment Using Biopiles - Provide two graphs, one showing cumulative removal of total VOCs and a second graph showing total contaminant biodegradation over time.
 - Ex Situ Soil Treatment Using Landspreading/Thinspreading - no graphs are needed.
- Time Versus Contamination Concentration Graphs. Create graphs with contamination level on the y axis (semilog scale) and time on the x axis (linear scale). If free product is present, time versus contamination concentration graphs are not necessary.

The recommended documentation for each remedial method is as follows:

- Groundwater Extraction and Product Recovery - graph the contaminant level over time for the groundwater that is extracted by the extraction system. List all compounds that exceed ch. NR 140 ES or PAL. If over five contaminants exceed ch. NR 140 ES or PAL, only list the five contaminants that exceed ch. NR 140 standards by the greatest percent.
 - In Situ Air Sparging - provide a graph for the single monitoring well that is most heavily contaminated. If over five contaminants exceed ch. NR 140 ES or PAL, only list the five contaminants that exceed ch. NR 140 standards by the greatest percent.
 - Natural Attenuation in Groundwater - provide a graph for all monitoring wells that contain any compounds that exceed ch. NR 140 standards. If over five contaminants exceed ch. NR 140 ES or PAL, only list the five contaminants that exceed ch. NR 140 standards by the greatest percent.
 - Soil Venting - provide a graph of contaminant concentration over time for the entire system for total VOCs. If any gas probes are used to assess subsurface conditions in either contaminated zones, also provide a graph with the data from the most heavily contaminated gas probe.
 - Natural Attenuation in Soil - provide a graph of contaminant concentration over time for total vapor phase VOCs as measured with an FID, oxygen, carbon dioxide and methane in an gas probe.
 - Ex Situ Soil Treatment Using Biopiles - no graph is necessary.
 - Ex Situ Soil Treatment Using Landspreading/Thinspreading - no graphs are needed.
- Graph of Contaminant Concentrations Versus Distance. If free product is present, a graph of contaminant concentrations versus distance is not necessary.

The recommended documentation for each remedial method is as follows:

- Groundwater Extraction and Product Recovery - no graph is necessary.
- In Situ Air Sparging and Natural Attenuation in Groundwater - plot a graph with distance (on the x axis, linear scale) and contaminant concentrations (y axis, log scale) from the upgradient measurement point to the farthest downgradient data point along the centerline of the plume. List the same contaminants as shown on the Time Versus Contaminant Concentration Graphs. Clearly show the source area on the graph. If free product has been present, label the data points that previously contained free product. For in situ air sparging, see comments above about samples collected from conventional monitoring wells with filter packs versus driven probes.

**OPERATION, MAINTENANCE, MONITORING
AND OPTIMIZATION REPORTING OF
SOIL AND GROUNDWATER REMEDIATION SYSTEMS**

Tables. Whenever possible, data over the life of the project should be listed.

The recommended documentation for each type of table is as follows:

• Groundwater Contaminant Chemistry Data.

List:

- Contamination levels for all contaminants that exceed ch. NR 140 standards.
- Dissolved oxygen levels if applicable.
- Other biological parameters, if applicable (nitrogen, phosphorous, manganese, sulphate, iron, dissolved methane, redox potential, pH, microbial population size, etc.). See instructions for page GW-3 for more information on these parameters. Also, list the dates the samples were collected and the standard methods used to analyze the samples.

• Groundwater Biological Parameters.

For natural attenuation in groundwater only, these measurements should be listed (if known) to provide information on biodegradation. This table is not necessary for free product extraction, groundwater extraction or in situ air sparging.

Provide a table that includes any results of tests conducted for dissolved oxygen, nitrate, manganese, iron, sulphate, methane, redox potential, heterotrophic and/or hydrocarbon degrading microorganism populations. Identify on the table if the monitoring locations are upgradient, side gradient, downgradient, or within the plume, dates of sampling, and the analytical methods used for those parameters. Include all data for the life of the project. Since some of these tests are only conducted once, or periodically - enter "NS" in the table for not sampled for any parameters that were not sampled during a particular round of sampling.

When asked to list the standard methods, list the method if a standard method exists. There are however some tests (for example dissolved methane) where there are no official standard laboratory or field methods. In this case the laboratory will have to create their own standard procedures. In these cases list the name of the laboratory and that laboratory's name for that test.

Specific considerations for each parameter are as follows:

- Dissolved oxygen (mg/L). The most efficient mechanism for natural or enhanced biodegradation of petroleum compounds is aerobic biodegradation.
- Nitrate (mg/L as N). Nitrate (NO_3^{-1}) is a potential electron acceptor for denitrification and also serves as a nutrient for heterotrophic microbial populations to enhance aerobic biodegradation. Decreasing nitrate levels from background wells to wells within the plume are an indication of either aerobic or anaerobic biodegradation.
- Manganese as Mn^{+2} (mg/L). Manganese as Mn^{+4} is converted to soluble manganese as Mn^{+2} under anaerobic biodegradation. For this reason, total manganese analysis is not appropriate, only soluble manganese as Mn^{+2} . When the levels of soluble manganese are higher in wells within the plume than in background wells, that is an indication of anaerobic biodegradation.
- Iron as Fe^{+2} (mg/L). Iron as Fe^{+3} is converted to soluble iron as Fe^{+2} under anaerobic biodegradation. For this reason, total iron analysis is not appropriate, only soluble iron as Fe^{+2} . When the levels of soluble iron are higher in wells within the plume than in background wells, that is an indication of anaerobic biodegradation.
- Dissolved sulphate (SO_4^{-2} , mg/L). Sulphate (SO_4^{-2}) is a potential electron acceptor. Decreasing sulphate levels from background wells to wells within the plume are an indication of anaerobic biodegradation.
- Dissolved methane (mg/L). Methane is produced under anaerobic conditions. Since background methane levels can usually be assumed to be zero, in most cases only measurements within the plume are used. Exceptions are when the natural soils have very high levels of TOC (for example peat), background methane levels are also warranted. When the contaminant is crude oil instead of a refined petroleum product, methane measurements may however cause erratic results. Significant amounts of methane may be created when other electron acceptors (NO_3^{-1} , Mn^{+4} , Fe^{+3} and SO_4^{-2}) are exhausted. For this reason, significant levels of methane are indicative of very very anaerobic conditions.
- Redox potential (millivolts, include + or - sign). Redox potential is another measure of the level of aerobic/anaerobic conditions, however it is a much more sensitive measurement than DO at very low levels of DO.
- Heterotrophic and hydrocarbon degrading microorganism populations (CFU/mL). Heterotrophic and specific hydrocarbon degrader population sizes should be listed for both background locations and locations within the plume, if there is information available. There is disagreement by many of the experts within the field as to the merits of sampling for this parameter. Refer to other DNR guidance documents on natural attenuation (or passive bioremediation) for more information on this topic.

• Groundwater Elevations.

Self explanatory.

• Soil Contaminant Chemistry Data.

Self explanatory.

**OPERATION, MAINTENANCE, MONITORING
AND OPTIMIZATION REPORTING OF
SOIL AND GROUNDWATER REMEDIATION SYSTEMS**

Tables (Continued).

· Soil Gas Data.

The recommended documentation for each remedial method is as follows:

- When natural attenuation in soil is used, provide a graph of all soil gas readings over time for every data point.
- When soil venting is used, if a gas probe is used to assess subsurface conditions over time in a location where air is not extracted, provide that data in a table.

· System Operational Data.

The recommended documentation for each remedial method is as follows:

- Groundwater Extraction and Product Recovery:
 - Well by well flow rates in gpm for each extraction well. If a well is off line, list flow rate as "ZERO." Clearly denote on the table periods of system shutdown.
- In Situ Air Sparging:
 - Air pressure and injection flow rates in scfm for each well. If a well is off line, list flow rate as "ZERO." Clearly denote on the table periods of system shutdown.
- Natural Attenuation in Groundwater - no table needed.
- Soil Venting:
 - Vacuum readings and extraction rates in scfm for each well. If a well is off line, list flow rate as "ZERO." Clearly denote on the table periods of system shutdown.
 - Air concentrations in ppm_v or in mg/L for total VOCs.
 - Total system contaminants removed in pounds and the pounds per day removal rate.
- Natural Attenuation in Soil - no table needed.
- Ex Situ Soil Treatment Using Biopiles:
 - If forced air ventilation is used:
 - System extraction rates in scfm.
 - Air concentrations in ppm_v for total VOCs.
 - Total system contaminants removed in pounds and the pounds per day removal rate.
 - Temperature.
 - If passive ventilation is used, a table of temperatures.
- Ex Situ Soil Treatment Using Landspreading/Thinspreading - no table is needed.

**OPERATION, MAINTENANCE, MONITORING
AND OPTIMIZATION REPORTING OF
SOIL AND GROUNDWATER REMEDIATION SYSTEMS**

Acronyms and Abbreviations:

CFU/mL	colony forming units per milliliter
cm/sec	centimeters per second
DATCP	Department of Agriculture, Trade and Consumer Protection
DCOM	Department of Commerce
DNR	Department of Natural Resources
DO	Dissolved Oxygen
DRO	Diesel Range Organics
ES	Enforcement Standards in NR 140
FID	Flame Ionization Detector
ft/yr	feet per year
gpd	gallons per day
gpm	gallons per minute
GRO	Gasoline Range Organics
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
NR	prefix for rules established by the DNR
P.E.	Registered Professional Engineer
P.G.	Registered Professional Geologist
PAL	Preventative Action Limit in NR 140
PECFA	the state sponsored cleanup fund for certain petroleum contaminated sites
ppm _v	parts per million by volume (vapor phase only)
scfm	standard cubic feet per minute
TOC	Total Organic Carbon
USCS	Unified Soil Classification System
USDA	United States Department of Agriculture
μg/kg	micrograms per kilogram
μg/mL	micrograms per milliliter
VOC	Volatile Organic Compounds
Y/N	Yes or No

**OPERATION, MAINTENANCE, MONITORING
AND OPTIMIZATION REPORTING OF
SOIL AND GROUNDWATER REMEDIATION SYSTEMS**

Example Calculations for Determining the Biodegradation Rate on Forced Air Biopiles.

Important Note: This page uses a nonproportional font and characters that are unique to WordPerfect. If the user received this document electronically, this page may need to be converted to a different font for the formulas to print correctly. The original font used for this page was prestige elite with 16.67 characters per inch.

Assumptions:

- The measurements at the stack are as follows:
 - Average flow rate is 20 scfm.
 - Average oxygen level extracted from biopile is 14.0 percent by volume.
 - Average carbon dioxide level extracted from biopile is 3.5 percent by volume or 35,000 ppm_v.
- Atmospheric air contains 21 percent oxygen by volume and 400 ppm_v (or 0.04 percent) carbon dioxide. (Note: On each site visit, the consultant should check atmospheric air to assure that the instrument is spanned correctly.)
- Atmospheric air weight 0.0763 pounds per cubic foot at standard temperature and pressure (Gibbs, 1971).
- Average molecular weight of air is 28.97 (Gibbs, 1971) which is rounded off to 29, molecular weight of O₂ is 32, molecular weight of CO₂ is 44.
- For every pound of contaminants biodegraded, 3.3 pounds of oxygen is utilized and up to 3.2 pounds of carbon dioxide is generated.

- The stoichiometry of aerobic benzene biodegradation can be described as follows:



Based on this, benzene biodegradation requires that 3.07 pounds of oxygen are utilized to fully oxidize one pound of benzene, assuming no electron acceptors other than oxygen are used. Assuming no biomass is produced and no geochemical reactions consume carbon dioxide, 3.38 pounds of carbon dioxide is generated from one pound of benzene.

- The stoichiometry of aerobic hexane biodegradation can be described as follows:



Based on the above assumptions, hexane biodegradation requires 3.52 pounds of oxygen and generates up to 3.06 pounds of carbon dioxide.

Other hydrocarbons also require a similar ratio of oxygen for aerobic biodegradation. For purposes of this guidance it is assumed that a pound of petroleum contamination requires 3.3 pounds of oxygen and generates up to 3.2 pounds of carbon dioxide and 1.1 pounds of water in the biodegradation reaction.

Calculations:

Oxygen utilization rate:

$$(0.21 - 0.14) * \frac{32}{29} * 0.0763 \frac{\text{pounds}}{\text{ft}^3} * 20 \frac{\text{ft}^3}{\text{min}} * 60 \frac{\text{min}}{\text{hour}} = 7.07 \frac{\text{pounds}}{\text{hour}}$$

Carbon dioxide production rate:

$$(0.035 - 0.0004) * \frac{44}{29} * 0.0763 \frac{\text{pounds}}{\text{ft}^3} * 20 \frac{\text{ft}^3}{\text{min}} * 60 \frac{\text{min}}{\text{hour}} = 4.81 \frac{\text{pounds}}{\text{hour}}$$

Biodegradation rate based on oxygen:

$$7.07 / 3.3 = 2.1 \text{ pounds per hour}$$

Biodegradation rate based on carbon dioxide:

$$4.81 / 3.2 = 1.5 \text{ pounds per hour}$$

Since the biodegradation rate is based on oxygen utilization and/or carbon dioxide generation, it is a measure of the overall biodegradation rate of all carbon sources, including natural organic carbon and any organic materials that were added. For this reason, the biodegradation rate is not specific to hydrocarbons and it is likely that the measured biodegradation rate will overestimate the rate of contaminant reduction.

Commonly the measured biodegradation rate based on carbon dioxide generation is less than the rate estimated with oxygen. Because of geochemical interferences and biomass formation, estimates based on carbon dioxide measurements are often low. If however the biodegradation rate estimate based on carbon dioxide is significantly greater than the estimate based on oxygen, it is likely that there is a measurement or calculation error. In this way, the carbon dioxide measurements can be used to double check the oxygen measurements and calculations.